



CHALLENGES ASSOCIATED WITH HORIZONTAL DIRECTIONAL DRILLING AND PIPING INSTALLATION UNDER A MAJOR HIGHWAY FOR THE REMEDICATION OF A PETROLEUM PLUME

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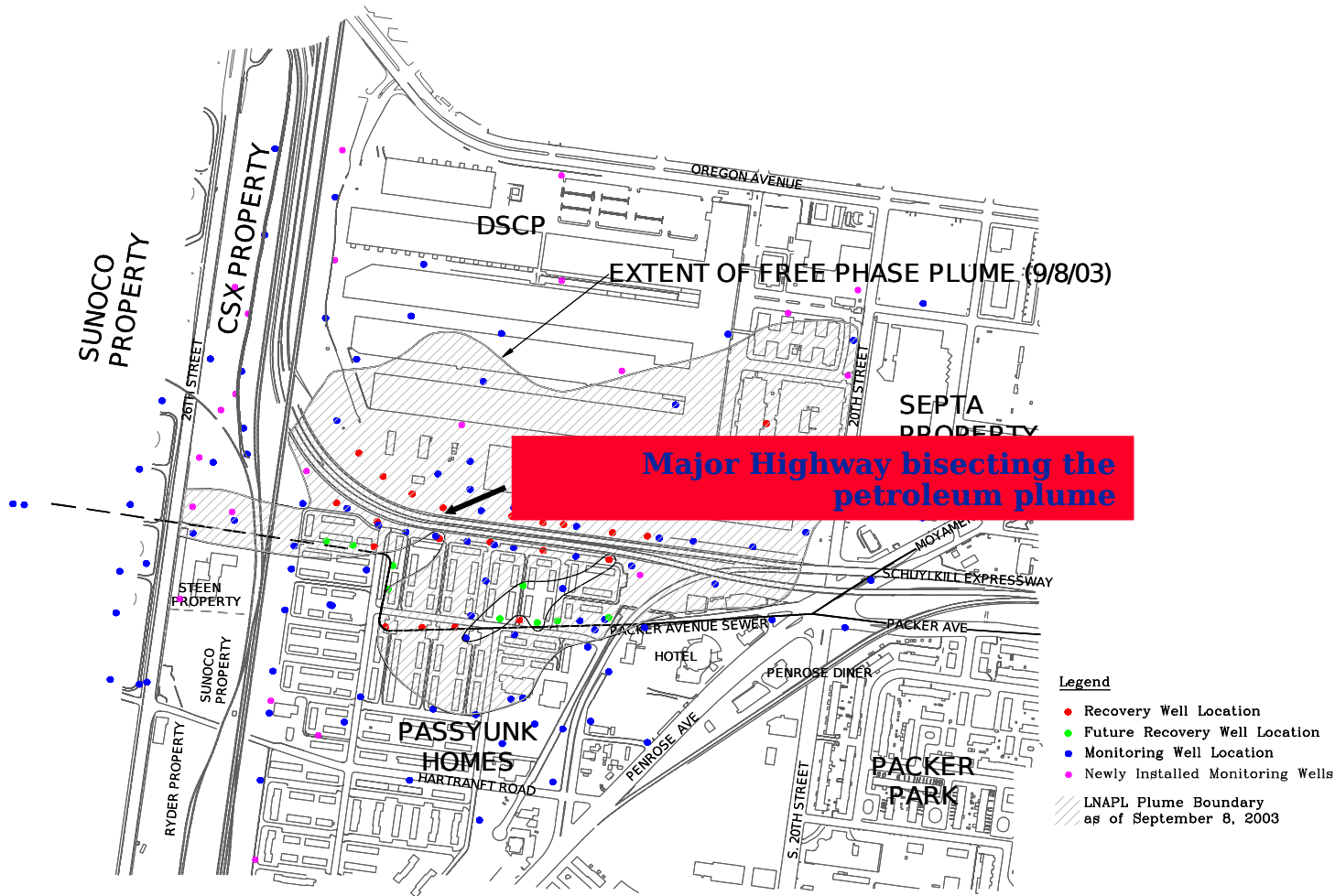
April, 2003





Site Background

- **A large free-phase refined petroleum plume (1-1.5 million gallons) underlies the former Defense Supply Center Philadelphia property, a major highway and a former housing development to the south.**
- **An existing remediation system has removed over 850,000-gallons of product (which does not include the 1 to 1.5 million gallons remaining).**





PRODUCT RECOVERY OPERATIONS

- **A Phase II Remediation vacuum enhanced skimming system is being installed to expedite the remediation efforts.**
- **Since the plume and recovery wells are transected by a major highway, the options included the installation of two separate remediation systems on two separate properties or a way to connect the wells on either side of the highway to one system.**



Proposed Remediation System

- If two systems were to be installed, it would have required the installation of two buildings.
- It would also have required the installation of a thermal oxidizer on both sides of the highway.



Close-Up of Thermal Oxidizer





Highway Bisecting the Petroleum Plume

- The highway that bisects the plume is the Walt Whitman Bridge Approach off the Schuylkill Expressway.
- This approach to the bridge is one of the main arteries in Philadelphia used by over 100,000 vehicles a day.





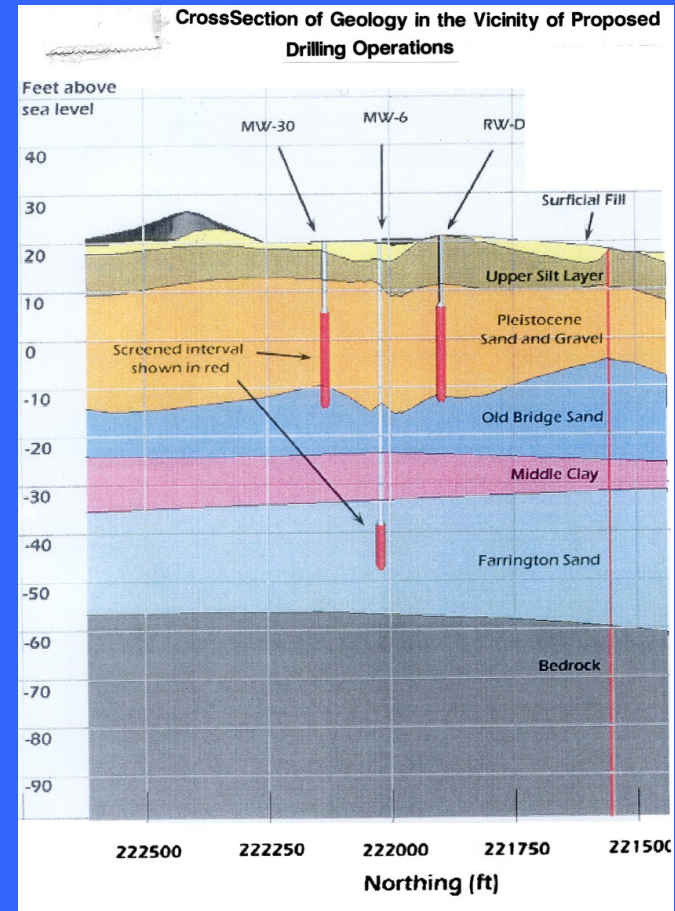
To Directionally Drill or Not to Drill

- **The risk of using horizontal directional drilling to install piping under the highway were weighed against the costs of having to install two separate remediation systems.**
- **It was determined that a cost savings of up to \$300,00 to \$400,000 would be realized if the recovery wells on both sides of the highway were connected up with piping to one system versus the installation of two systems on both sides of the highway.**



Geological Evaluation for Risk Mitigation

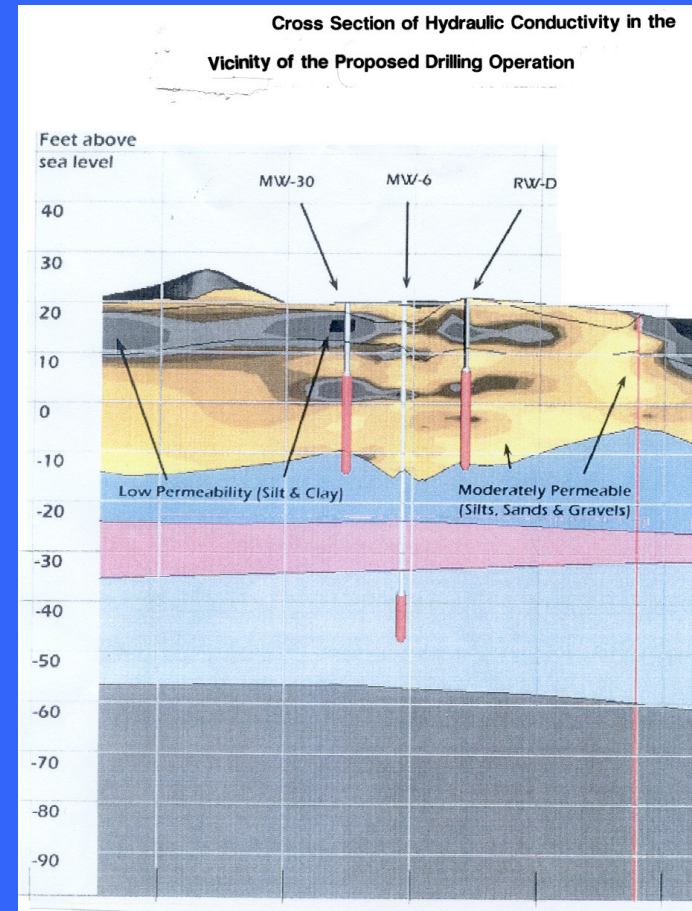
- Borehole path selection and a review of the geology are very important for ensuring a successful drilling operation.
- Existing soil boring logs were used to evaluate the geology in the vicinity of the proposed piping run.





Geological Evaluation for Risk Mitigation

- A dense silt layer was identified at an average depth of 9-feet below grade and 5 to 9 feet thick.
- The distribution and geotechnical characteristics of this silt layer were extensively studied during a prior risk assessment.





Determination of Directional Drilling Borehole Depth

- **The proposed depth of the borehole was determined to be 12-feet below grade.**
- **This would place the borehole just below the silt, but above the free-phase petroleum plume.**
- **The proposed depth would also be at least 3 feet below the sanitary sewer line under the highway.**



Contingencies and Traffic Control

- **Several meetings were held involving engineers, geologists, and the owners of the highway to discuss the methodologies, potential traffic problems and contingencies.**
- **A Contingency and Traffic Control Plan was prepared and submitted.**



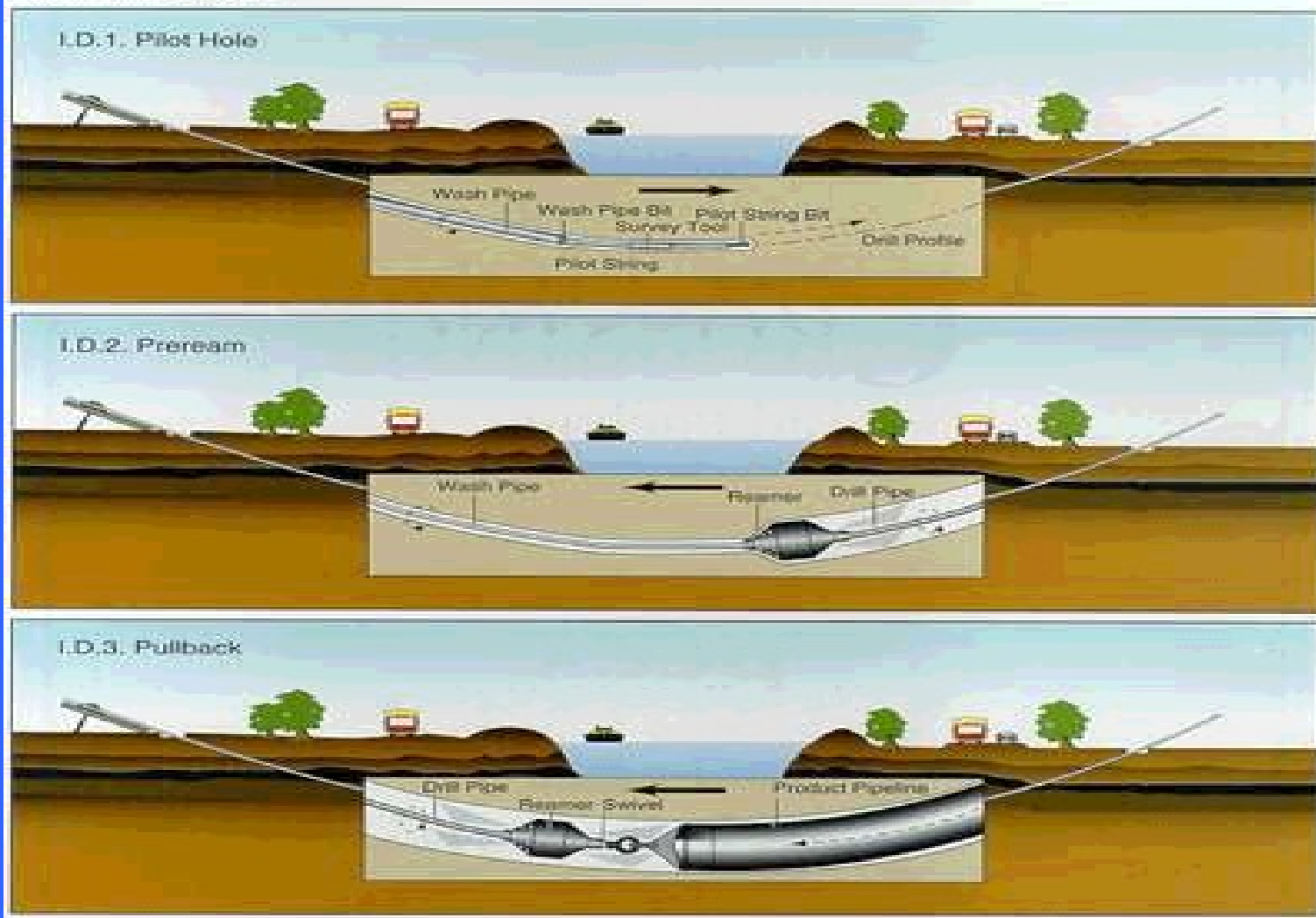
Contingencies and Traffic Control

- **Contingencies were established for:**
 - ◆ **Partial or complete highway collapse;**
 - ◆ **“Frac-out” or drilling mud being pushed to the surface of the highway;**
 - ◆ **Partial highway or full-highway shut-down procedures.**
 - ◆ **Detour routes were established and agreed upon by all responsible parties.**



HORIZONTAL DIRECTIONAL DRILLING

Figure 1. Technique





DIRECTIONAL DRILLING OPERATIONS FACING SOUTHEAST





DIRECTIONAL DRILLING RIG





Pilot Hole Drill Bit





DRILLING BITS USED FOR DIRECTIONAL DRILLING





TANKS USED TO MANAGED THE DRILLING MUD DURING THE DRILLING OPERATIONS





TANKS (BLUE) USED TO STORE DRILLING MUDS PRIOR TO OFF-SITE DISPOSAL





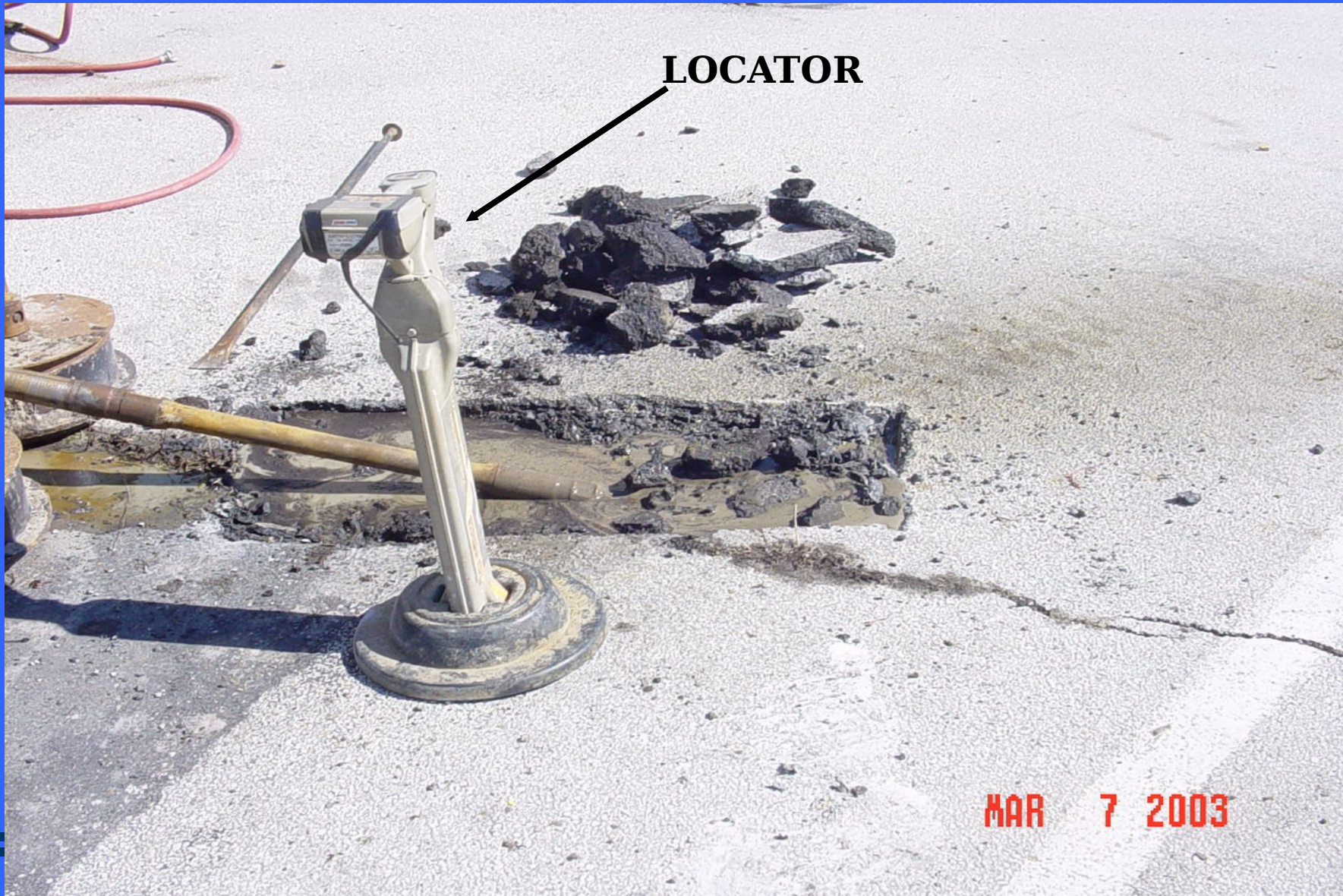
PILOT HOLE BEING DIRECTIONALLY DRILLED



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ABOVE-GRADE LOCATOR USED TO LOCATE THE DEPTH AND ORIENTATION OF THE DRILLING BIT





EXCAVATION THROUGH THE PATH OF THE DIRECTIONAL DRILLING TO SHOW DRILLING BIT BEING ADVANCED UNDERGROUND



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PIPING THAT WAS FUSED AND INSTALLED UNDER THE HIGHWAY





FUSION MACHINE BEING USED TO FUSE OR "WELD" THE PIPE TOGETHER





LARGE SECTIONS OF THE PIPE BEING FUSED TOGETHER





EXCAVATION ON PASSYUNK HOMES TO ACCESS DRILLING BITS AND INSTALL THE PIPING



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END OF PIPE TO BE PULLED UNDER THE HIGHWAY WITH THE DRILLING RODS





PIPING BEING PULLED FROM PASSYUNK HOMES, UNDER THE HIGHWAY, ONTO DSCP





18-INCH DIAMETER PIPING ABOUT TO BE PULLED UNDER THE HIGHWAY





Lessons Learned-Upfront Planning

- It is extremely helpful to prepare a presentation to the stakeholders on exactly what you are proposing for the drilling operations.
- This approach saves time and money by allowing questions to be raised and addressed prior to the submittal of any plans





Lessons Learned-3rd Party Backup on Borehole Stability

- A Study on the annular space around pipes installed by horizontal directional was submitted with the Work Plan.
- This provided third-party evidence that there was no concern over the collapse of the annular space around the pipe and the highway.

Cross Sections Cut Along Piping Runs

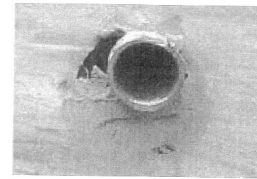


FIGURE 3-29. 100mm (4 in.) Sand Excavation @ 4 weeks

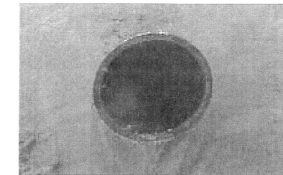


FIGURE 3-32. 100mm (4 in.) Sand Excavation @ 1 year



FIGURE 3-30. 200mm (8 in.) Sand Excavation @ 4 weeks



FIGURE 3-33. 200mm (8 in.) Sand Excavation @ 1 year



FIGURE 3-31. 300mm (12 in.) Sand Excavation @ 4 weeks



FIGURE 3-34. 300mm (12 in.) Sand Excavation @ 1 year

(Source: Arianraturum, 2001)



Lessons Learned-Proper Geological Information

- It is important to have good and accurate geological data in the area of the proposed directional drilling pathway.
- If this data is not available, then the appropriate drilling operations should be conducted to obtain the data.





Lessons Learned-Traffic Control

- It is necessary to prepare a comprehensive Traffic Control Plan to address any expected and unexpected problems.
- It was agreed to set-up detour routes with all the signs in place prior to the work beginning.
- The detour routes required the hiring of specialized subcontractors.





Lessons Learned-Preparation for Frac-Out

- **“Frac-Out” is the inadvertent return of drilling fluid being forced up to the ground surface.**
- **The drilling fluid is pumped into the directional drilling borehole at 1,000 psi, which could force the drilling fluid into preferential pathways (natural and manmade).**
- **The geological analyses plays an important role evaluating the potential for frac-out to occur.**



Lessons Learned-Preparation for Frac-Out

- **It is important to ensure that there is proper drilling fluid circulation. If the drilling fluid circulation is restricted, it could cause extreme pressures resulting in a frac out.**
- **It is important to have a direct line of communication (cell phone, walkie-talkie) between the driller and the spotter at the exit pit to establish that there is circulation and relay any problems.**



Lessons Learned-Preparation for Frac-Outs

- **While every upfront precaution should be taken to ensure frac-out does not occur, there should be contingencies in place in the event it occurs.**
- **Drilling mud is comprised of bentonite and polymers, which are extremely slippery. The drilling mud creates a severe slip hazard if it is spilled.**
- **The depths in which frac-out may occur should be determined based upon the geology and then the rig and borehole angle should be situated in a position that would result in the frac-out occurring in the least dangerous location.**



Lessons Learned-Preparation for Frac-Outs

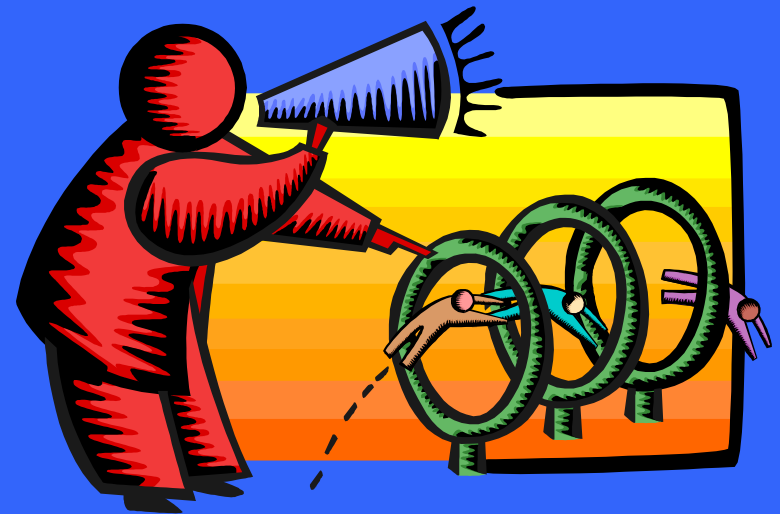
- Where possible, the overland portion of the drilling route should be roped off.
- This area should be patrolled to look for surface expressions of any frac-outs.
- Hay bails should be available in order to help contain the drilling fluid in the event of a frac-out.
- A vacuum truck should be made available to vacuum any spilled drilling fluid as well as handle the drilling fluid itself.





Lessons Learned-Unexpected Costs

- The owners of the highway or the stakeholders may require additional work as part of the access agreement.
- We had to agree to survey the elevation of the highway before the drilling and quarterly thereafter to ensure there was no subsidence.
- We were also responsible for paying the costs for the highway owner's consultant to oversee the work.





- **In Conclusion, when properly managed and planned, directional drilling can be an effective and cost effective method for the installation of piping.**

